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RELATIONSHIPS AMONG REPEATED SPRINT TESTS AND AEROBIC FITNESS IN ADOLESCENT TENNIS PLAYERS

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ABSTRACT

The aim of this study was to determine the performance indices (ideal sprint time – IS, total sprint time – TS, and performance decrement – PD) of two repeated sprint test (RST) and to examine their relationships with the aerobic fitness of young tennis players. Fifteen young (age 14.7±1.0 yrs) tennis players performed three tests: an aerobic power test (20 m shuttle run), and two different RST protocols (12×20 m and 12×10 m runs). Peak heart rate was significantly higher in the 20 m protocol compared to the 10 m protocol while no significant difference was found in the PD of the two RST protocols. Significant positive correlations were found between the ISs and the TSs (r=0.946 and r=0.932, respectively), but not between the PDs of the two RST protocols. Significant negative correlations were found between TS and IS and aerobic fitness during the 10 m protocol (r=–0.594 and r=–0.595, respectively) and the 20 m protocol (r=–0.757 and r=–0.716, respectively), but not between PD and the aerobic fitness in both RST protocols. Both short and long RST protocols represent similar anaerobic capabilities. In addition, the aerobic energy system serves as a significant factor in both RST protocols. However, it seems that the involvement of the aerobic system is more significant in the long than in the short repetition RST protocol.

Keywords: *repeated sprint test, tennis, aerobic, fitness, anaerobic fitness*

INTRODUCTION

Tennis is an intermittent-type game characterized by repeated intense short activities with short periods of rest between efforts. The duration of work and rest periods during a tennis match is 1–10 s and 10–20 s, respectively [3, 10]. The total match time in tennis could last between 60 to 210 min with a single point length of 1–10 s. The precise match time and intensity is dependent upon the style of play (attacking or defensive), type of court surface (soft or hard), and motivational aspects [6, 12]. In addition, environmental factors have been reported to influence the pattern of activity and recovery, and the physiological responses, during the game [2, 10]. The average physiological responses to a tennis match have been reported to be rather modest, with mean exercise intensities less than 60–70% of maximal oxygen consumption (VO_2max) and mean heart rates of 60–80% of maximum values. Blood lactate concentrations usually remain low (1.8–2.8 mmol/l) during tennis match [9, 10]. However, occasionally, during long and intense rallies, lactate concentration may increase up to 7 mmol/l, suggesting increased use of anaerobic glycolytic processes to supply energy [14].

The small dimensions of tennis court (11.9 m long and 8.2 m wide) limit the maximal sprint length. The short high-intensity type activities in the game rely mostly on anaerobic breakdown of creatine phosphate for energy production in the activated muscles. Consequently, tennis may be classified as a mainly anaerobic type of sport [8, 15]. However, despite the start-and-stop nature, tennis has also an aerobic component because high-energy phosphates used for immediate muscle energy requirements are predominately resynthesized by oxidation during recovery periods [7, 19].

One reliable [4] and valid [1] method of evaluating the athlete's ability to repeatedly performed high intense efforts is the repeated sprint test (RST). This test usually involves repetitions of short sprints, with variable short recovery periods in-between. The specific test protocol can be easily adapted to suit the specific needs and activity patterns of intermittent-type sports. RSTs are most commonly used in multi-sprint team sports such as soccer, rugby, and hockey. Surprisingly, the RST have never been performed among young tennis players.

The aim of the present study, therefore, was to determine the performance indices and the physiological responses of two RST (10 m and 20 m repetitions) protocols and to examine their relationships with the aerobic fitness in young tennis players.

MATERIALS AND METHODS

Participants

Fifteen young trained male tennis players (age 14.8±1.0 yrs, body mass 64.9±7.4 kg, height 159.9±7.6 cm) participated in the study. The players had average of 5–6 yrs playing experience. The players had four tennis training sessions a week, each of 2 hrs. They also had three tennis-specific conditioning sessions a week, 45 min each, including agility, speed and specific coordination drills. Participants competed in occasional tournaments, every few weeks throughout the year, with a total of 20 to 25 matches per year. A standard calibrated scale and stadiometer were used to determine height and body mass. The study was approved by the Institution's ethical committee, the testing procedure was explained, and a written informed consent was obtained from all players and their parents.

Testing procedures

The participants performed three tests in random order, separated by 4 to 5 days from each other and at least 48 hours prior or after to a match. The three tests included an aerobic power test, and two RSTs. In order to prevent unnecessary fatigue effect, players and coaches were instructed to avoid intense training 24-hours prior to each testing session. The aerobic power test and the two RSTs were performed in the team home sports arena. All tests were performed in the afternoon, three hours after lunch and in a comfortable average air temperature of about 24 °C.

Repeated sprint test

Prior to the RSTs participants performed a 20–25 min specific warm-up. Each RST protocol included a series of short maximal running with short rest periods between runs. The two protocols consisted of the following parameters;

1. Twelve times all-out 10 m sprint departing every 20 s
2. Twelve times all-out 20 m sprint departing every 20 s

A 10 m and a 20 m all-out sprints were performed following the warm-up of the 12×10 m and the 12×20 m protocols, respectively, by each subject. The time for each sprint was used as the criterion score during the subsequent RST. In the first sprint of each RST, subjects were required to achieve at least 95% of their criterion score. If 95% of the criterion score was not achieved, the subject was required to re-start the RST. A photoelectric cell timing system (Alge-Timing Electronic, Vienna, Austria) linked to a digital chronoscope was used to record each sprint and rest interval time with an accuracy of 0.001 s. During the recovery between sprints, subjects tapered down and slowly walked back to the next start point. Two sets of timing gates were used, working in opposite directions, to allow subjects to start the next run from the same end that they finished the preceding sprint, thus eliminating the need to hurry back to a common starting point. A standing start, with the front foot placed 30 cm behind the timing lights, was used for all sprints. Timing was initiated when the subject broke the light beam. An experimenter was placed at each end of the track to give strong verbal encouragement to each subject at each sprint. Subjects were instructed prior to the test to produce maximal effort for each sprint and to avoid pacing themselves.

The three measures for each RST (12×10 m and 12×20 m) were the ideal 10 m or 20 m sprint time (IS), the total accumulated sprinting time (TS) of the 12 sprints of each RST, and the performance decrement (PD) during each test. IS was calculated as the fastest 10 m or 20 m sprint time multiplied by 12. TS was calculated as the sum of all sprint times. PD was used as an indication of fatigue and was calculated as [(TS/IS)X100]–100 [4]. The test-retest reliability of running RST is 0.942 for TS, and 0.75 for PD [4].

Heart rate was measured using a Polar heart rate monitor (Polar Accurex Plus, Polar Electro, Woodbury, NY) immediately upon completion of each repeated test.

Aerobic power test – twenty-meter shuttle run test

The 20 m shuttle run test is a field test that predicts aerobic fitness (VO_2max) and has been shown to be a reliable and valid indicator of aerobic power in various populations [16]. The test consisted of shuttle running at increasing speeds between two markers placed 20 m apart. A portable compact disc (Sony CFD-V7) dictated the test pace by emitting tones at appropriate intervals. Subjects were required to be at one end of the 20 m course at the signal. A start speed of 8.5 km/hour was maintained for one minute, and was increased by 0.5 km/hour every minute thereafter. The test score achieved was the number of 20m laps completed before the subject either withdrew voluntarily from the test or failed to arrive within 3m of the end line on two consecutive tones. VO_2max was derived by the formula: Y=6.0X–24.4, where y=predicted VO_2max and X=maximum speed achieved [18].

Statistical Analysis

Paired t-test was used to compare differences between the performance indices (IS, TS, PD) and heart rate following the two RSTs. Pearson correlations were computed between performance indices of the two RSTs (12×10 m and 12×20 m) and between each RST and the calculated VO_2max. Data are presented as mean±SD. Significance level was set at $p<0.05$.

RESULTS

Performance indices of both sprints protocols (short – 12×10 m and long – 12×20 m) are presented in Table 1. IS and TS were significantly higher in the long compared to the short RST protocol (41.98 vs 23.36 s and 43.24 vs 24.18 s, respectively). PD in the long protocol was higher, although not significantly, compared to the short protocol (3.6 and 3.0%, respectively). Peak heart rate was significantly higher at the end of the long protocol (181.7 b/min) compared the short protocol (168.2 b/min).

Table 1. Performance indices (Mean±SD) of the two RST protocols

Protocol	Ideal Sprint Time (s)	Total Sprint Time (s)	Performance Decrement (%)	Peak Heart Rate (b/min)
12×10 m	23.36±1.74*	24.18±1.74*	3.6±2.3	181.7±13.1*
12×20 m	41.98±3.18	43.24±3.26	3.0±1.0	168.2±11.3

Note: *p<0.05 for between-test differences

The correlations between performance indices of the two RST protocols are presented in Table 2. Significant correlations were found between the IS (r=0.946) and between the TS (r=0.932), but not between the PD (r=–0.180), of the two RST protocols. Significant correlations were also found between the 12×20 m TS and the 12×10 m IS (r=0.938) and between the 12×20 m IS and the 12×10 m TS (r=0.948) of the two RST protocols. No significant correlations were found between the 12×10 m PD and the 12×20 m IS or TS. No significant correlations were also found between the 12×20 m PD and the 12×10 m IS or TS.

Table 2. Relationships between performance indices in the two RST protocols

RST Protocol	Indices	12x10 m Ideal Sprint Time	12x10 m Total Sprint Time	12x10 m Performance Decrement
12x20 m	**Ideal Sprint Time**	0.946*	0.948*	–0.350
	Total Sprint Time	0.938*	0.932*	–0.112
	Performance Decrement	0.081	–0.142	–0.180

Note: *Significant correlation at p<0.05

Table 3 presents the correlations between the calculated VO_2max and the performance indices of both RSTs. Significant correlations were found between the IS or the TS and VO_2max in the short protocol (r=–0.595 and r=–0.594, respectively). Significant correlations were also found between the IS or the TS and the VO_2max in the long protocol (r=–0.716 and r=–0.757, respectively). No significant correlations were found between each of the two protocols PD and the VO max.

Table 3. Relationships between calculated VO_2max and performance indices in the two RSTs

RST Protocol	Performance indices	VO_2max
12×10 m	IS	–0.595*
	TS	–0.594*
	PD	–0.083
12×20 m	IS	–0.716*
	TS	–0.757*
	PD	–0.345

*Significant correlation at p<0.05

DISCUSSION

The findings of the present study display strong significant relationships between matched performance indices of the short and long RST protocols. In addition, a significant correlation was found between the athlete's aerobic fitness (calculated VO_2max) and the TS or the IS in both RSTs.

The physiological responses to intermittent exercise depend primarily on the subject's ability to recover from periods of work, and on the specific protocol used. Thus, performance depends on the duration of repetitions, duration of rest periods, and number of repetitions performed in a given work session.

Different protocols for RST consist of 6–12 all-out sprints intercepted by rest intervals of 20 to 40 s. The specific test protocol is adapted to suit the specific needs and activity patterns of the specific sport. The mean duration of work and rest periods in tennis are 1–10 s and 10–20 s, respectively [3, 10, 17]. Therefore, short sprints and short periods of recovery seem to be appropriate for RST in tennis. The strong correlations between the performance indices of the two RSTs in the present study may confirm that both protocols represent similar physiological entities and that both are applicable for tennis. In a similar study, Meckel et al. [13] found only low to moderate correlations between matched performance indices of two RST protocols in a group of soccer players. However, in that study one RST protocol involved 12×20 m while the other included 6×40 m. Thus, it seems that although they used the same repeated activity pattern and perform an equal total work, the RSTs were different from one another and may represent different physiological entities. These results emphasize the need for a selection of an appropriate RST protocol – one that will match the work-rest pattern and physiological demands of the relevant sport. Although the present findings demonstrate physiological resemblance between the two RSTs, one should consider the influence of the court surface and its application on game activity patter. Therefore, given that clay court tennis matches are relatively slow and long lasting and grass court matches are usually fast and short [11], the long 12×20 m RST may better suit clay specialist players while the short 12×10 m RST may better suit grass specialist players [16].

The relevance of the aerobic energy system to power maintenance during intermittent activity was evaluated in the present study by a correlation coefficient analysis between the performance indices in each RST and the calculated VO_2max of the participants. Significant correlations were found between the IS or the TS and VO_2max in the short protocol ($r=-0.595$ and $r=-0.594$, respectively). Significant correlations were also found between the IS or the TS and the VO_2max in the long protocol ($r=-0.716$ and $r=-0.757$, respectively). The assumption that the aerobic energy system is an important determinant in recovery rate from intense activity and therefore assists in power output maintenance during the RST, relies on the fact that creatine phosphate re-synthesis occurs primarily by oxidative processes [7, 19]. However, results of previous studies were inconsistent and reported non-significant to moderate correlations ($0.42<r<0.62$) between VO_2max and performance indices in intermittent type of activity [1, 7, 13, 19]. One possible reason for these differences may come from the fact that these studies used different protocols with large variations in the number and length of repetitions and time of rest periods. Obviously, although using a repeated activity pattern, the differences between protocols may change the energy demands and the physiological responses during the RSTs. Only when the RST protocol is specific to the sport involved and truly represent its movement pattern, a valid conclusion can be made concerning the relationship between VO_2max and RST performance indices and the importance of aerobic fitness to power maintenance in that sport. However, if the movement pattern of a given sport is complex (as in tennis) and an appropriate protocol is difficult to identify, two protocols should be tested, as was done in the present study. The findings of our study suggest that the aerobic system is involved in the energy regulation of both RST protocols. However, it seems that the greater the total work, the greater the involvement of the aerobic energy system. In line with that, Gatanos et al. [5] suggested that the aerobic energy system contribution to the total energy provision increased significantly, and was more important (as compared to glycolysis) in power output maintenance during a long series of repeated sprints. They speculated that during the last sprinting efforts, glycolysis was exhausted and the contribution of the aerobic system to ATP re-synthesis was more significant. The longer total sprint and running time of the long protocol (12×20 m) in the present study, and our finding of stronger correlation between TS in the long RST and the calculated VO_2max, seems to be consistent with this theory. Again, one should also consider the fact that tennis matches on hard surface courts (e.g., grass) are usually short and intense compared to the relatively slow and long games performed on soft surface courts (e.g., clay). Given that, it seems that the involvement of the aerobic fitness to tennis is more important in clay surface matches.

In conclusion, short repetition RST (12×10 m) protocol and long repetition RST protocol (12x20 m) seem to represent similar physiological entities and performance capabilities. Therefore, both protocols seem to be appropriate for tennis. In addition, the aerobic energy system serves as a significant factor in both short and long RTS protocols. However, the higher total work performed in the long repetition RST leads to a greater involvement of the aerobic system in the long, compared to the short, RST protocol. The results also highlight the possible greater importance of aerobic fitness for soft surface tennis players compared to hard surface specialist. Consequently, soft surface specialist should include more aerobic-type training in their conditioning program than hard surface specialist.

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